Studies on Esophageal Reconstruction by Means of the Pedunculated Gastric Tube with Additional Micro-vascular Anastomoses

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by

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INTRODUCTION

The esophageal reconstruction by means of the gastric tube, especially the KIRSCHNER-NAKAYAMA type, in which approximately all of the anal portion of the stomach is transplanted in the isoperistaltic direction[24], is a safe and useful method after the resection of thoracic esophageal carcinoma. Especially after the resection of carcinoma of the upper two thirds of the thoracic esophagus, the operation can be performed more safely by transplanting this gastric tube antethoracically[28]. In our clinic, therefore, esophageal reconstruction by this gastric tube has been adopted as an ordinary procedure.[11] On the other hand, the HEIMLICH-GAVRILIU type of reversed gastric tube[6)-8)53)54)], which is constructed from the greater curvature of the stomach in the antiperistaltic direction combining with splenectomy, is also worthwhile in some cases, in which the defects of the esophagus at a higher portion have to be replaced. At the tip of these gastric tubes, however, necrosis is often caused by the disturbance of blood supply, which results in the sutural insufficiency at the site of the esophagogastric anastomosis. If the tips of these gastric tubes are revascularized by adding the micro-vascular anastomosis, the disturbance of blood circulation there may be eliminated to a great degree, and the results of esophagogastrostomy can be improved. However, some difficulties are frequently encountered by this procedure because of the arteriosclerotic changes in the arterial wall which exist at a high percentage in patients of the cancer age[56]. And there is no definite opinion which is more important, the arterial or the venous anastomosis on such occasions.[1] In this presentation, the present author has investigated the hemodynamics and the oxygen tension in the subserous tissue at the tip of the gastric tube after the performance of the micro-vascular anastomosis and the postoperative oxygen therapy.

METHOD OF EXPERIMENT

1. Materials

Adult mongrel dogs ranging in weight from 9 to 30 kg were used. The animals were anesthetized with intravenous administration of pentobarbital sodium (25 to 30 mg per kg), and, when necessary, with additional doses of pentobarbital sodium or inhalation of ether.

2. Operative procedure to create the gastric tubes

a. The KIRSCHNER-NAKAYAMA type of gastric tube. The stomach was isolated and severed below the cardia and transplanted in the isoperistaltic direction into the subcutaneous

portion of the thorax. In this procedure, the right gastric, right gastroepiploic vessels and vascular arcades along the greater and lesser curvatures were preserved carefully. The left gastric vessels were severed near their origins in such a manner that the blood flow to their ascending branch was preserved. The splenic vessels were ligated and divided within the hilus of the spleen in order to preserve the origins of the left gastroepiploic and short gastric vessels, and the spleen was resected. Further, the splenic vessels were isolated and severed just distal to the origins of the left gastric vessels from the splenic vessels, and the splenic artery and vein were anastomosed to the left common carotid artery and to the left external jugular vein, respectively, by means of INOKUCHI's vessel suturing apparatus[13)-17)] (Senko Medical Instruments Mfg. Co., Japan) mainly and NAKAYAMA's vessel suturing apparatus[29)30)] (Senko Medical Instruments Mfg. Co., Japan) in a few cases (Fig. 1).

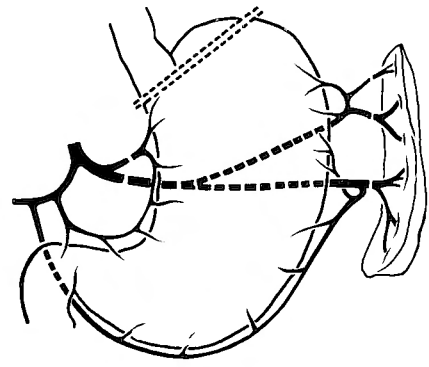

Fig. 1. Operative procedure to create the *Kirschner-Nakayama* type of gastric tube.

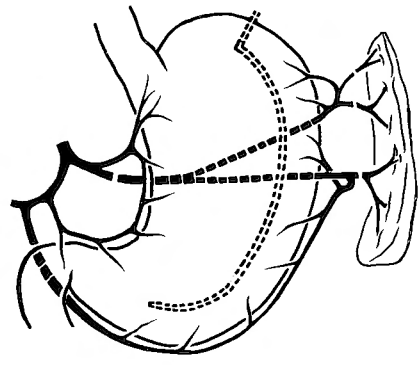

Fig. 2. Operative procedure to create the *Rutkowsky* type of gastric tube.

b. The RUTKOWSKY type of gastric tube.[4)46)] This gastric tube 2 cm in diameter was created from the greater curvature of the stomach. This tube remained attached to the stomach at the antrum about 6 cm oral to the pylorus. The cardiac end of the tube was brought upward subcutaneously, accompanied by its blood supply from the gastroepiploic vessels. The gastric tube suturing clamp designed by IZUKURA (Shirai Co., Japan), which had a curve corresponding to that of the greater curvature, was used. The right gastroepiploic vessels and the vascular arcade along the greater curvature were preserved. The splenic vessels were isolated and divided in the same manner as in the KIRSCHNER-NAKAYAMA type of gastric tube, and anastomosed to the left common carotid artery and to the left external jugular vein. In these cases in which the RUTKOWSKY type of gastric tubes were constructed and where the dogs survived the first operation, the tip of the gastric tube was anastomosed to the divided cervical esophagus in the second operation (Fig. 2).

3. Studies on the hemodynamics and tissue oxygen tension at the tip of the gastric tube

a. Measurement of tissue oxygen tension. Tissue oxygen tension was measured by the polarographic method. Clark electrode (Yellow-Spring Co., America) which was capped with 0.05 mm thick teflon film was used. For the purpose of calibration, the physiological saline solutions which showed the same temperature as in the tissue of the

gastric tubes and definite oxygen tension, were used. The properties of these saline solutions were checked by Beckman Model 160 Physiological Gas Analyzer (Beckman Instrument Inc., America). When the temperature of the physiological saline solutions differed from that of the gastric tube, the values were amended according to the standard curve prescribed by the special character of the electrode. Details will be described in the discussion. The polaroelectrode was fixed at the tip of a pick-up arm which was movable up and down, and placed tightly on the serosal surface of a portion 3 cm anal from the tip of the gastric tube, lest the movement of the electrode caused by respiratory action should disturb the polarographic measurement. As a polarographic apparatus Yanagimoto's Polarorecorder PR-2 and Potential Scanner AP-20 (Yanagimoto Co., Japan) were used.

Considering the characteristics of the polaroelectrode, it was placed tightly on the serosal surface at the tip of the gastric tube. Then, the tissue oxygen tension was measured under the following conditions : (1) When the arterial and venous anastomoses were performed at the tip of the gastric tube, (2) thereafter, when the anastomosed artery was occluded, (3) when the anastomosed vein was occluded, and (4) when both the anastomosed artery and vein were occluded.

b. Measurement of the amounts of blood flow through the anastomosed vessels. An electromagnetic flowmeter of gated-sine wave type (Model FM-6R Microflo, Medicon Inc., America) was used for this purpose. The amounts of blood flow through the anastomosed vessels and the splenic vessels were measured under the following conditions : (1) The blood flow through the splenic vessels just before the severance of the splenic vessels following the construction of the gastric tube, (2) the blood flow through the anastomosed artery after the arterial and venous anastomoses were performed, (3) the blood flow through the anastomosed artery after the anastomosed vein was occluded, (4) the blood flow through the anastomosed artery after the right gastroepiploic vessels were occluded, (5) the blood flow through the anastomosed vein after the arterial and venous anastomoses were performed, (6) the blood flow through the anastomosed vein after the anastomosed artery was occluded, and (7) the blood flow through the anastomosed vein after the right gastroepiploic vessels were occluded.

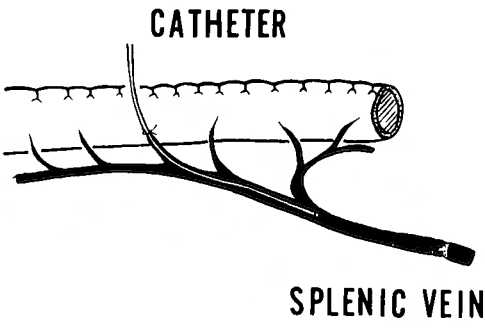

Fig. 3. Catheterization for measurement of the venous pressure at the tip of the gastric tube.

c. Measurement of venous pressure. A thin polyethylene catheter was inserted from a branch of the left gastroepiploic vein into the splenic vein and the venous pressures were measured under the following conditions : (1) After the arterial and venous anastomoses were performed, (2) thereafter, when the anastomosed vein was occluded, and (3) when the anastomosed artery and vein were occluded (Fig. 3).

4. **Studies on the effect of combination of the postoperative oxygen therapy.** A semicylindric oxygen tent which had capacity of 65 liters was made for this purpose. In this experiment, a cranial portion

from the neck only was admitted into the oxygen tent, for fear that the gaseous oxygen in the tent should directly affect the polaroelectrode. The values of the tissue oxygen tension at the tip of the gastric tube were recorded continuously by the polarographic method (1) when the arterial and venous anastomoses were performed and (2) when the venous anastomosis alone was performed.

RESULTS

1. Gastric tube

a. The KIRSCHNER-NAKAYAMA type of gastric tube. The lengths of the gastric tubes varied from 14 to 25 cm. The xiphoid process was partially resected, and when almost all of the stomach was used, the tip of the gastric tube was transplanted to the height of the major pectoral muscle or more upward in most cases. The color of the gastric tube was normal after the vascular anastomoses were performed.

b. The Rutkowsky type of gastric tube. The lengths of the gastric tubes varied from 15 to 22 cm, and the gastric tubes were brought upward to the height of the major pectoral muscle in most cases. In these cases in which the xiphoid process was resected partially and the circulation at the tip of the gastric tube was well preserved, the gastric tube could be transplanted 4 to 5 cm above the major pectoral muscle. Two cases of nine survived this operation. In these cases no necrosis was observed at the tip of the gastric tube. It was proved by angiographic studies and by autopsies 70 days and 10 months after operation that the anastomosed artery and vein were kept open and the anastomotic regions of the vessels were lined with intima (Table 1, Figs. 4, 5 and 6).

2. Tissue oxygen tension at the tip of the gastric tube

Figures 7 and 8 represent the tissue oxygen tension in the KIRSCHNER-NAKAYAMA and RUTKOWSKY types of gastric tubes In these gastric tubes, (1) the value of tissue oxygen tension was highest when the arterial and venous anastomoses were performed, (2) it decreased to one third to half of the value in (1) within 5 minutes after the anastomosed artery was occluded, (3) reduction of tissue oxygen tension was less than in (2) when the anastomosed vein alone was occluded, and (4) reduction was most remarkable when the anastomosed artery and vein were occluded. As a whole, reduction of tissue oxygen tension in (2), (3) and (4), were more remarkable in RUTKOWSKY's tube than in KIRSCHNER-NAKAYAMA's tube.

3. Amounts of blood flow through the anastomosed vessels

Table 2 represents the amount of blood flow. (1) Even after the anastomosis between the splenic and the common carotid arteries was performed, the blood flow through the anastomosed artery did not increase. (2) When the anastomosed vein was occluded, 55 % decrease in input arterial flow through the anastomosed artery was observed in KIRSCHNER-NAKAYAMA's tube and 28 % decrease in RUTKOWSKY's tube. (3) When the anastomosed artery was occluded, 36 % decrease in output venous flow was observed in KIRSCHNER-NAKAYAMA's tube and 23 % decrease in RUTKOWSKY's tube. (4) Reductions in the blood flow after occlusion of the anastomosed vessels were more remarkable in those cases in which the arcade of the left and right gastroepiploic vessels, that is, one of the collateral channels, was poor. (5) When the right gastroepiploic vessels were occluded, no remarkable change was observed in the blood flow through the anastomosed vessels, when

Table 1. The Kirschner-Nakayama and Rutkowsky types of gastric tubes constructed in dogs.

Kirschner-Nakayama type of gastric tube				Rutkowsky type of gastric tube			
Dog No.	Body weight (kg)	Length of the gastric tube* (cm)	Height of the tip of the gastric tube	Dog No.	Body weight (kg)	Length of the gastric tube (cm)	Height of the tip of the gastric tube
1	11	22	upper margin of m. p. m.**	6	12	—	middle of m. p. m.
3	14	18	middle of m. p. m.	9	12	19	lower margin of m. p. m.
53	12	18	5 to 6 cm upward m. p. m.	10	9	21	lower margin
54	15.5	21	3 cm upward	12	10	21	lower margin
52	13	22	upper margin	13	10	16	lower margin
55	9	20	lower margin	15	9	—	4 cm upward m. p. m.
56	30	21	middle	16	14.5	20	2 cm upward
				11	13	15	2 cm downward
33	9	17	5 cm downward	20	10	20	lower margin
30	9	14	3 cm downward	22	9	18	lower margin
31	12	17	3 cm downward	14	11	20	lower margin
32	9	15	5 cm downward	17	14	22	5 cm upward
34	30	25	lower margin	25	12	21	lower margin
35	9	14	3 cm downward	42	13.5	15	5 cm downward
36	11.5	15	4 cm downward	43	18	15	2 cm downward
37	9.5	14	2 cm downward	44	16	15	4 cm downward
29	10	18	1 cm downward	45	13.5	17	3 cm downward
39	9	15	lower margin	46	13	22	1 cm downward
40	10	15	lower margin	47	19	22	upper margin
41	10	14	4 cm downward	48	14.5	15	2 cm downward
				49	10	15	lower margin
				50	10	15	lower margin
				51	12	15	lower margin
				57	21	21	middle

In dogs No. 1, 3 and 52 to 56 approximately the whole stomach was used for Kirschner-Nakayama's tube.

* Length from the xiphoid process.

** m. p. m. represents the major pectoral muscle.

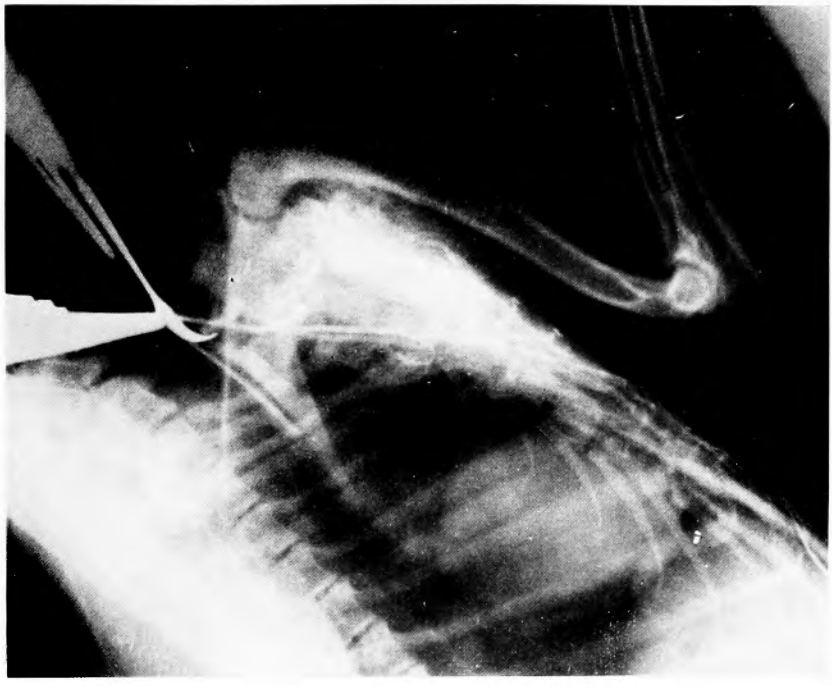

Fig. 4. An angiogram demonstrating complete patencies of the anastomosed artery and vein 70 days after the first operation. Injection of contrast medium was done from the anastomosed artery, that is, left common carotid artery (Dog No. 13. The *Rutkowsky* type of gastric tube).

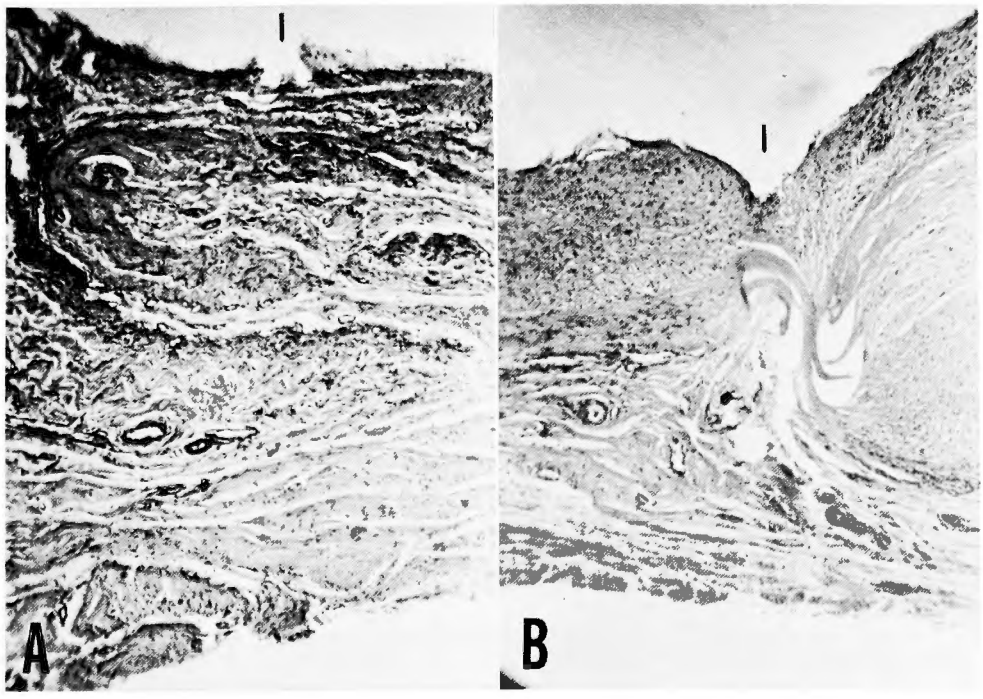

Fig. 6. Photomicrographs of the anastomotic regions of the artery (A) and vein (B). The anastomotic regions (↙) were lined with intima.

Fig. 5. Photographs of the anastomotic regions of the artery (A) and vein (B).

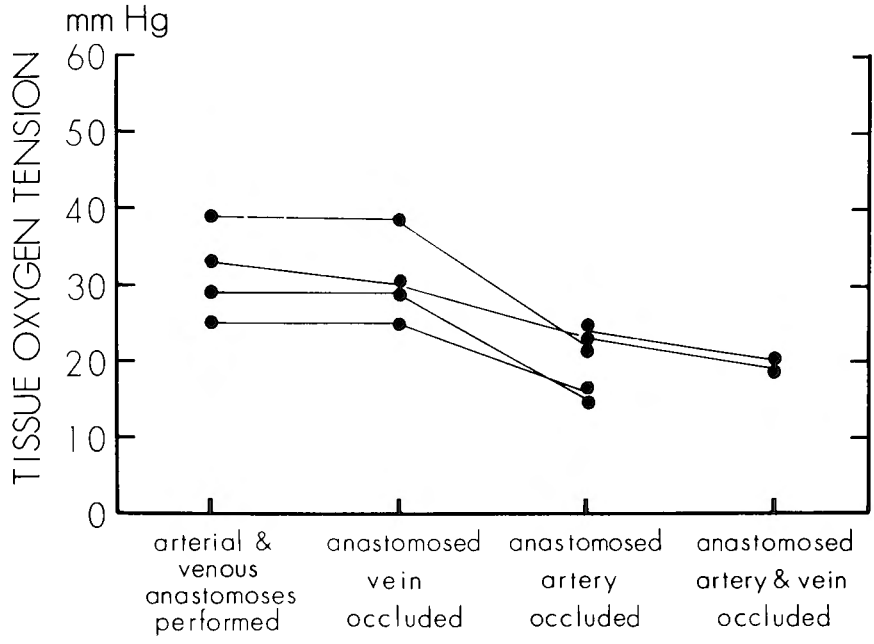

Fig. 7. Changes in the tissue oxygen tension at the tip of the *Kirschner-Nakayama* type of gastric tube.

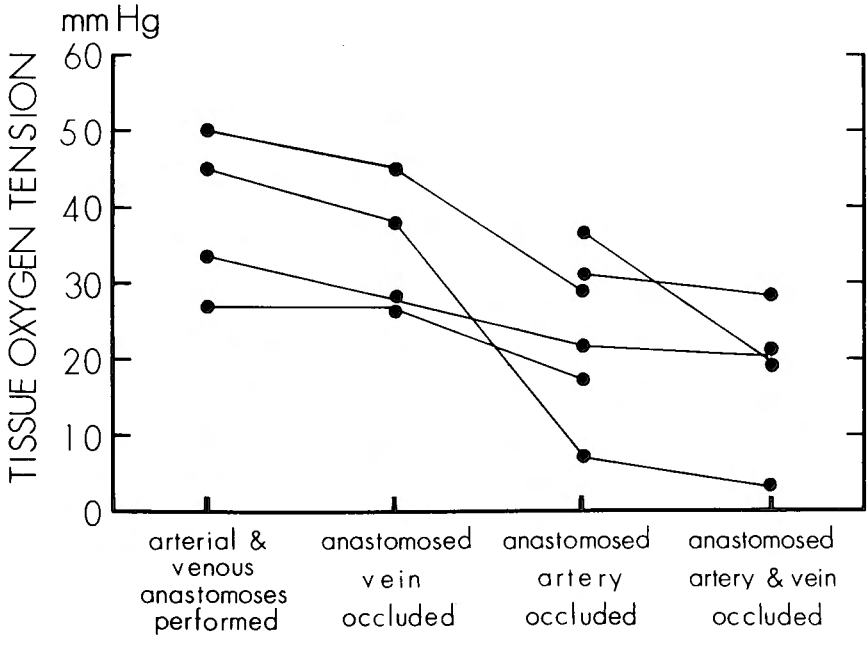

Fig. 8. Changes in the tissue oxygen tension at the tip of the *Rutkowsky* type of gastric tube.

Table 2. Amounts of blood flow through the anastomosed vessels and the splenic vessels.

Dog No.	Gastric tube	Arterial flow (cc/min.) Before anastomoses: Splenic artery — Splenic vein kept open	Arterial flow After anastomoses: Anastomosed artery — Anastomosed vein kept open	Anastomosed vein occluded	R. gastroepiploic vessels occluded	Venous flow (cc/min.) Before anastomoses: Splenic vein — Splenic artery kept open	Venous flow After anastomoses: Anastomosed vein — Anastomosed artery kept open	Anastomosed artery occluded	R. gastroepiploic vessels occluded
53	**Kirschner-Nakayama**	—	26	—		—	27	21 (78%)	—
54	Kirschner-Nakayama*	43	31	15 (49%)		33	31	15 (49%)	—
52	Kirschner-Nakayama	—	31	—	—	—	52	38 (73%)	—
56	Kirschner-Nakayama**	—	34	14 (40%)	34	69	48	27 (56%)	—
49	Rutkowsky	—	12	11.5 (—)	11.2	—	13	12 (92%)	12
50	Rutkowsky	—	39	20 (51%)	-	—	29	18 (62%)	17
57	Rutkowsky	—	8.5	5.2 (61%)	8.5	—	5.2	—	—
51	Rutkowsky	—	16	12 (75%)	—	—	27	—	—

* The communication between the left and right gastroepiploic vessels was not vigorous.
** The arteria gastrolienalis[55] was ligated.

the anastomosed artery and vein were kept open.

4. Venous pressure

(1) When the venous anastomosis was performed, the value of venous pressure remained under 150 mmH_2O. (2) When the anastomosed artery alone was kept open and the anastomosed vein was occluded, the value of venous pressure was higher than that which was measured when no vascular anastomosis was kept open (Table 3).

5. Effect of combination of the postoperative oxygen therapy

(1) As a preliminary experiment an intratracheal intubation was performed in dogs and it was ascertained that a typical rise in tissue oxygen tension was observed following 100% oxygen breathing. (2) The oxygen content inside the oxygen tent varied from 45 to 60 % at a flow rate of 12 liters per minute. (3) In KIRSCHNER-NAKAYAMA's tube the use of the oxygen tent caused a 67 % increase in tissue oxygen tension when the arterial and venous anastomoses were performed, and a 76 % increase when the venous anastomosis alone was performed. In RUTKOWSKY's tube the use of the oxygen tent caused a 68 % increase in tissue oxygen tension when the arterial and venous anastomoses were performed, and a 53 % increase when the venous anastomosis alone was performed (Table 4, Figs. 9 and 10).

DISCUSSION

SAKAKIBARA constructed the KIRSCHNER-NAKAYAMA type of gastric tube, nourished by the right gastric

Table 3. Venous pressure at the tip of the gastric tube (mm H_2O).

Dog No.	Gastric tube	Arterial and venous anastomoses kept open	Arterial and venous anastomoses occluded	Arterial anastomosis kept open, venous anastomosis occluded
52	Kirschner-Nakayama	110	230	320
56	Kirschner-Nakayama	150	330	580
49	Rutkowsky	100	335	—
50	Rutkowsky	65	360	520
57	Rutkowsky	125	335	550

Table 4. Rise (average value) in tissue oxygen tension at the tip of the gastric tube caused by use of oxygen tent (Flow rate : 12 liters/min.).

	Case of arterial and venous anastomoses	Case of venous anastomosis
Kirschner-Nakayama's tube	67%	76%
Rutkowsky's tube	68%	53%

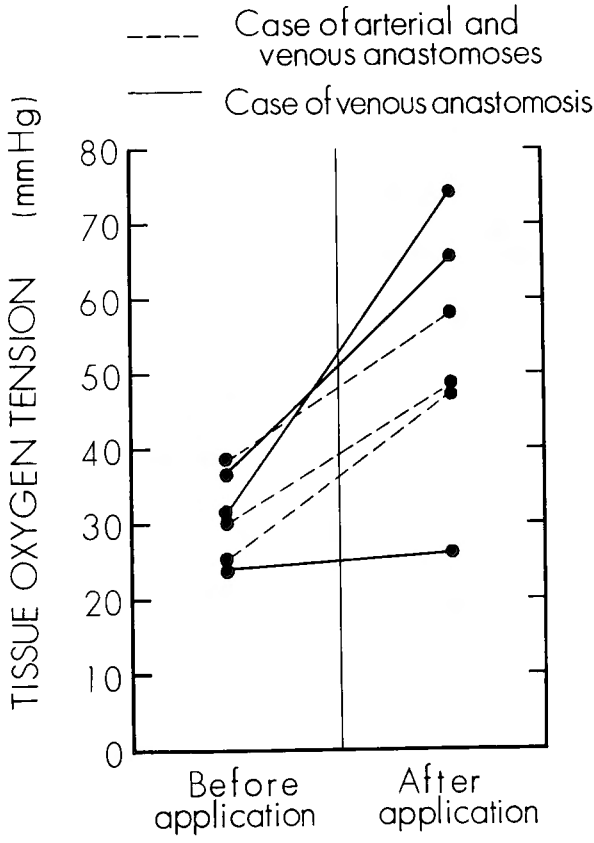

Fig. 9. Effect of application of the oxygen tent on the tissue oxygen tension at the tip of the *Kirschner-Nakayama* type of gastric tube (Flow rate : 12 liters/min.).

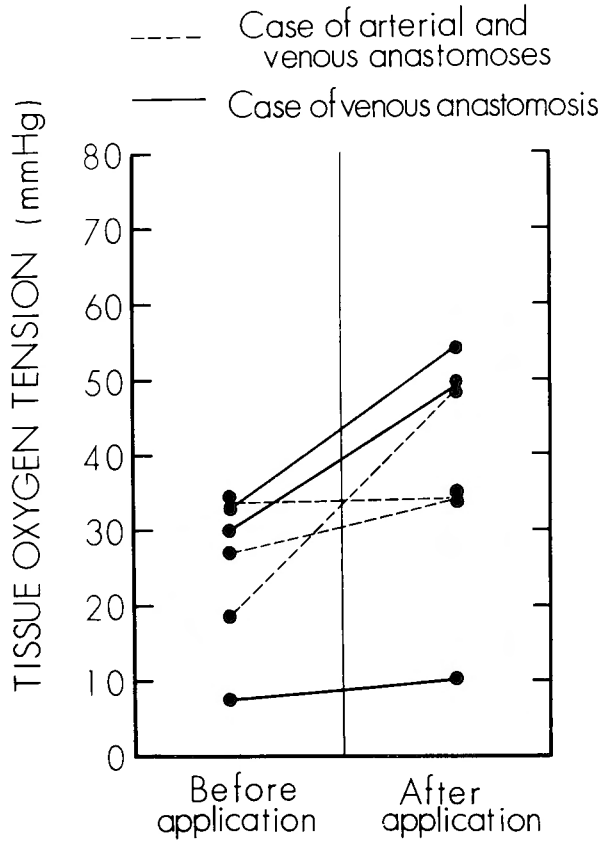

Fig. 10. Effect of application of the oxygen tent on the tissue oxygen tension at the tip of the *Rutkowsky* type of gastric tube (Flow rate : 12 liters/min.).

and gastroepiploic arteries, in dogs.[42] The lengths of the gastric tubes were only 16 cm on an average from the xiphoid process, and the tip of the gastric tube did not reach the lower margin of the major pectoral muscle. Although in his experiment necrosis at the tip of the gastric tube was not observed, OSAWA pointed out that the disturbance of blood circulation in the gastric tube occurred frequently when it was brought upward antethoracically.[37] Therefore, an attempt was made to eliminate the disturbance of blood circulation at the tip of the gastric tube by anastomosing the splenic vessels to the vessels in the neck. In my experiment, the KIRSCHNER-NAKAYAMA type of gastric tube was transplanted to the height of the upper margin of the major pectoral muscle or 3 to 5 cm upward and could be anastomosed to the cervical esophagus in almost all of the cases when approximately the whole stomach was available. However, in those cases where the gastric region supplied by the short gastric arteries could not be revascularized, a long gastric tube was not obtained.

According to SAKAKIBARA, the lengths of the RUTKOWSKY type of gastric tubes constructed in dogs varied from 13 to 15 cm.[42] As in his experiment the left gastroepiploic artery and the posterior ascending gastric branch of the splenic artery (Ramus gas-

tricus posterior ascendens) as well as the splenic artery were preserved, the length of the antethoracically transplanted gastric tube was restricted. However, according to the result of my experiment in which the splenic artery and vein were severed distal to their origins and were anastomosed to the cervical vessels, the gastric tube was long enough to be transplanted to the height of the lower margin of the major pectoral muscle or more upward in 17 cases among 24 cases. If the continuity between the gastric tube and the residual stomach is severed at the base of the gastric tube after it is constructed, brought upward, and its tip is revascularized, this gastric tube becomes a type of the free graft and the problems of irrigation are resolved. This must be considered in the preparation of a completely free graft. In those cases in which the circulation at the tip of the gastric tubes could not be improved by the vascular anastomoses, the gastric tubes remained 15 to 18 cm in length. Although, as OSAWA poined out, the lateral suture line in the gastric tube was very long,[37] bleeding and contamination of the operative field were minimized and the tuck of the gastric wall into the lumen at the suture line could be reduced by the use of IZUKURA's gastric tube suturing clamp.

The right gastroepiploic vessels in dogs were too small in diameter to perform the vascular anastomoses and to examine the hemodynamics in the HEIMLICH-GAVRILIU type of reversed gastric tube.

As to the method of esophageal replacement by the stomach or the bowel whose tips were revascularized by the vascular anastomoses, LONGMIRE (1947) reported a method in which the anastomoses between the internal mammary and the mesenteric vessels were performed by hand at the tip of the pedunculated segment of the jejunum[25], and since then various methods have been devised and reported.[2)3)9)10)17)-22)29)-36)38)39)44)52)57)-59)] As there was no arteriosclerotic changes in the arteries of dog which were often seen in man, the arterial and venous anastomoses were performed easily by the use of INOKUCHI's vessel suturing apparatus.

To evaluate the state of the circulation or the effect of revascularization in the myocardium or the brain, the polarographic method has been used frequently by means of a platinum electrode of open tip type[27)40)41)49)]. However, it is impossible to measure the absolute value of tissue oxygen tension by this electrode.[40)60)] According to my experience also, the measurement by this electrode was disturbed by the movement effect, solute effect and poisoning (aging) of the electrode, and it was difficult to record continuously for a long time.[12)] And there may be the ununiformity in meter readings due to the character of the region where the electrode was inserted and the property of the electrode itself[60)]. A Beckman needle type electrode (Oxygen Microelectrode, Beckman Instrument Inc., America) was suitable to insert into the brain, but unsuitable to insert into such a hard tissue as the stomach. Therefore, the present author used Clark electrode[12)] (Yellow Spring Co., America) which was placed tightly on the serosal surface. The electrode was fixed at the tip of a pick-up arm which was movable up and down, lest the movement of the electrode caused by respiratory action should disturb the polarographic recording. The electrode was capped with 0.05 mm thick teflon film[50)] which had high permeability to oxygen, and as a result, the response time of this electrode was shortened. However, current readings of an oxygen tension which is measured in viscous liquid represents an

extremely lower value, as compared with those measured in gas with the same oxygen tension.[43] For example, by the use of 0.001 mm thick teflon film, the current readings of an oxygen tension which is measured in serum is equal to approximately 80 % of those measured in gas.[47] Therefore, for the purpose of calibration, the physiological saline solutions were used which showed a definite oxygen tension and were prepared as follows: (1) Oxygen free saline solution. This could be made within 5 minutes by adding a bit of one % Na_2SO_3 solution into the saline solution.[48] This method is simple and excellent. (2) The saline solution which contains an equal amount of oxygen to that in the air. The oxygen tension of this solution was calculated from the known room temperature. (3) The saline solution saturated by oxygen. The current readings of oxygen tension in these three kinds of saline solutions represented linear correlation. The oxygen contents of these saline solutions represented the constant values in the measurement by Beckman Physiological Gas analyzer. According to my experiment, this polaroelectrode showed the change of about ± 3.8 % in its sensitivity in response to the change of ±1°C in temperature. As the temperature of tissue drops when it is exposed in the cold air, the experiment must be performed at 20 to 26°C. Calibration was accomplished by the use of the saline solutions which showed the same temperature as found in a tissue, and when it was impossible, the values were amended according to the standard curve prescribed by the special character of the electrode. The oxygen tension in a tissue, that is, in a tissue fluid could not be measured directly with the Clark electrode as with an electrode of open tip type.[45] However, when the electrode was placed tightly on serosa, the same pattern was obtained as that obtained by the use of a platinum electrode of open tip type. Namely, there was a typical rise in tissue oxygen tension following 100 % oxygen breathing, a decrease following regional artery occlusion and a return following release of occlusion, when the electrode was placed on an area of the gastric tube with an effective arterial circulation, as ROGERS pointed out. And these changes were initiated within 30 seconds. This showed the same pattern as ROGERS had obtained in the myocardium by the use of a platinum electrode of open tip type.[41]

As to the results of meaurement of tissue oxygen tension in the gastric tube, the typical pattern as above-mentioned was seen in every case. Although the present author examined on polarography the effect of change of temperature which was caused by occlusion of the anastomosed artery, no significant change of temperature was recognized during a short time. From the results of polarography, it was proved that the arterial anastomosis was more effective at the tip of the gastric tube for elevating the tissue oxygen tension, while the effect of venous anastomosis was rather smaller.

The amounts of blood flow in the gastric tube for esophageal reconstruction, not only in cases of free graft transplantation but also in cases of pedunculated graft transplantation, are smaller than that in the transplanted kidney.[23] It was proved that the flow through the anastomosed vein was extremely reduced by a change in the venous channel, that is, kinking, distortion or partial stenosis. Therefore, attention should be given to make the length of vein adequate and to choose the accurate technique of the vessel anastomosis. The performance of arterial anastomosis increased the venous return from the gastric tube, and therefore, reduced the risk of thrombosis in the region of venous anastomosis and

it was effective for the anastomosis of vein to be kept open. On the other hand, the performance of venous anastomosis could increase the input flow through the artery into the gastric tube. From these points of view, the performance of both arterial and venous anastomoses is desirable, when it is possible.

INOKUCHI and his associates pointed out that the pressure of the ileocoecal vein rose to 450 to 580 mmH_2O and the venous return was impaired after the right colon was brought upward to the neck when the pedunculated segment of the right colon was nourished only by the middle colic vessels, and they stressed that the additional anastomosis of vein was most important. And they proved that when the venous return from the jejunal segment was impaired, the irreversible decrease in the flow of the mesenteric artery occurred within 30 minutes.[17)-22)] NAKAYAMA and his associates performed only the anastomosis between the splenic artery and an artery in the neck in the antethoracic esophagogastric anastomosis, and they said that the venous anastomosis was not always necessary,[29)30)] but it should be performed concurrently when the stagnation at the tip of the gastric tube has occurred.[58)] However, recently they said, both the arterial and venous anastomoses should be performed.[59)] NISHIMURA and his associates indicated that in the pedunculated transplantation of the colon the arterial anastomosis was necessary when the value of arterial pressure at the tip of a graft remained under 70 mmHg, while the venous anastomosis was necessary when the venous pressure showed a value over 300 mmH_2O.[35)] From the result of my experiment, there occurred macroscopically remarkable venous stagnation at the tip of the gastric tube within one minute after occlusion of the anastomosed vein, and the gastric tube assumed cyanotic tone, and edema developed at the tip of the gastric tube within 10 minutes. These changes accompanied with remarkable rise in the venous pressure were observed also when the vessel anastomosis was not performed. The values of venous pressure ranged from 320 to 580 mmH_2O when the arterial anastomosis alone was performed.

MATSUO and his associates at our clinic studied on the blood circulation in the HEIMLICH-GAVRILIU type of gastric tube by P^{32} (radio-phosphorus) labelled erythrocytes. And they proved that the site of the measurement came near the tip of the gastric tube, the radio-count decreased gradually, but the rise in radio-count was observed at the tip of the gastric tube.[26)] It was thought to be caused by the venous stagnation there. And in my experiment on the RUTKOWSKY type of gastric tube, lowering in tissue oxygen tension at the tip of the gastric tube following the occlusion of the anastomosed vessels was more remarkable, as compared with the KIRSCHNER-NAKAYAMA type of gastric tube. Therefore, when the communication between the left and right gastroepiploic arteries is not vigorous, especially in the HEIMLICH-GAVRILIU and RUTKOWSKY types of gastric tubes which are nourished only by the gastroepiploic vessels, the performance of micro-vascular anastomoses are thought to be very significant.[55)]

The use of antethoracically transplanted RUTKOWSKY type of gastric tube with additional micro-vascular anastomosis to replace or by-pass the esophagus has the following advantages: This tube is long enough to replace the esophageal defect at a higher portion. And as the splenic vessels may be brought upward together with this tube, the revascularization of the tip of the gastric tube is performed easily, as compared with the

HEIMLICH-GAVRILIU type of gastric tube. Besides, with this type of the gastric tube, (1) the residual stomach retains its nutritional and storage functions, (2) the mediastinal structures and lungs are not compressed, and (3) the vagus nerves may be preserved, as seen in the use of the HEIMLICH type of gastric tube. The obvious clinical indication for the use of this operative procedure would be an obstructing lesion of the esophagus of a malignant or benign nature, especially when it would not be necessary to perform the resection of the thoracic esophagus and the removel of involved abdominal lymph nodes.

ISHIGAMI and his associates at our clinic proved that as a result of the disturbance of blood circulation at the tip of the gastric tube, cathepsin, comprised in the gastric wall, was activated, and then necrosis was brought about, which was mainly responsible for sutural insufficiency at the anastomosed region of the antethoracic esophagogastrostomy. The cathepsin is an enzyme which has SH-radical as an active one and reacts decomposingly in weak acid and reductive system and resolves the auto-tissue protein near the isoelectric point and reacts synthetically in alkaline and oxidative system. And they have demonstrated that the massive oxygen therapy after the operation of esophagogastric anastomosis was effective because the gastric catheptic activity was markedly inhibited, and they have applied clinically this therapy with good results.[11] Although in the series of my experiment the oxygen content inside the oxygen tent was approximately 45 % on an average, the remarkable rise of the tissue oxygen tension at the tip of the gastric tube was observed not only in the case in which both the arterial and venous anastomoses were performed but also in the case in which the venous anastomosis alone was performed, when dogs were admitted into the oxygen tent. In the future, by applying the hyperbaric oxygen therapy more remarkable effects should be obtained to improve the result of esophageal reconstruction.

SUMMARY AND CONCLUSION

The KIRSCHNER-NAKAYAMA and RUTKOWSKY types of gastric tubes were constructed in dogs and the tip of the gastric tube was revascularized with the additional microvascular anastomoses. And the present author investigated the hemodynamics at the tip of the gastric tube from several points.

(1) The highest value in tissue oxygen tension was obtained in the case in which the arterial and venous anastomoses were performed. In the case in which the arterial anastomosis alone was performed, a slightly lower value was obtained. The case in which the venous anastomosis alone was performed, showed only a slightly higher value, as compared with the case in which no vascular anastomosis was performed.

(2) According to the result of measurement of the blood flow through the anastomosed vessels, (A) the venous return increased by adding the arterial anastomosis, and (B) the arterial input flow increased by adding the venous anastomosis and by removing the venous stagnation.

(3) The venous pressure at the tip of the gastric tube could be lowered and the hemodynamics could be improved by adding the venous anastomosis at the tip of the gastric tube.

(4) A remarkable rise in tissue oxygen tension was obtained by the combination of

the postoperative oxygen therapy in the cases in which the tip of the gastric tube was revascularized by adding the arterial and venous anastomoses, or the venous anastomosis alone.

From these results the following conclusions were obtained:

(1) The revascularization by adding the arterial and venous anastomoses is most desirable in the pedunculated gastric tube for esophageal reconstruction.

(2) Venous anastomosis is always possible to perform even in such clinical cases where arterial anastomosis is impossible to perform because of the severe arteriosclerotic changes. By adding the venous anastomosis at the tip of the gastric tube accompanied with postoperative oxygen therapy, remarkable elevation of the tissue oxygen tension is obtained, and the purpose of the prevention against sutural insufficiency at the site of the esophagogastric anastomosis should be achieved.

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（和文抄録）

細小血管吻合を追加した有茎胃管による食道再建術に関する研究

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有茎胃管を使用して胸廓前食道再建術を行なつた際，挙上した胃管先端部に血行障害に起因する壊死が発生し，食道胃吻合部に縫合不全の起ることがしばしば経験される．そこでこれら胃管先端部に細小血管吻合を行なつて血行を再建し，血行障害を改善し，したがつて吻合の成功率を向上せしめようとする試みがなされている．しかし癌年令の患者に高い頻度において存在する高度の動脈硬化性病変はしばしばこの細小動脈吻合の施行を困難にすることがある．有茎胃管による食道再建術において，動脈吻合あるいは静脈吻合のいずれを追加することがより重要であるかについては意見の一致をみない現状である．そこで，著者は犬を用い Kirschner-中山式および Rutkowsky 式胃管を作製し，これらの胃管先端部に動・静脈吻合を追加し，

1）胃管先端部において漿膜下の組織酸素分圧をポーラログラフ法により測定した．

2）吻合血管を流れる血液量を電磁流量計を用いて測定した．

3）胃管における吻合静脈である脾静脈の静脈圧を直接測定した．

以上から胃管の血行動態ならびに動・静脈吻合追加の意義に関して検討を加えた．以上の結果，

1）長期間生存した実験犬では，胃管先端部に壊死は認められず，術後70日および10ヵ月に血管撮影法および剖検によつて調べたところ，吻合動・静脈は開存し，血管の吻合部は内膜によつておおわれていることが認められた．

2）ポーラログラフの面からみると，動・静脈吻合をともに行なつた場合が最も高い組織酸素分圧を示し，動脈吻合のみを行なつた場合にはこれよりやや低値を示し，静脈吻合のみを行なつた場合には，吻合を全く行なわなかつた場合に比してやや高い値を示すにすぎなかつた．

3）吻合血管の血流量を測定した成績によると，静脈血還流量は，動脈吻合を追加することによつて増加した．動脈血流入量は静脈吻合を追加し，うつ血を除去することによつて増加した．

4）胃管先端部に静脈吻合を追加することによつて，胃管先端部の静脈圧を低下させ，血行動態を改善することができた．

5）動・静脈吻合および静脈吻合を追加した胃管においても，術後酸素療法を併用することによつて，組織酸素分圧は著明に上昇した．

以上の諸成績から次のような結論を得た．

1）動・静脈吻合をともに施行して血行を再建することが最も望ましい．

2）臨床例において動脈硬化がつよく動脈吻合が不可能である場合においても，静脈吻合は常に施行可能であるから，静脈吻合の追加に術後酸素療法を併用すれば胃管先端部の組織酸素分圧は著明に改善され，食道胃吻合部における縫合不全防止の目的を達成することができるものと思われる．